Phys 131 2016

Lecture 12

Tues: Discussion /quiz

Supp Ex: 27, 28

Ch 5 Conc. Q 4, 5

Ch 5 Prob 14, 34, 46, 49

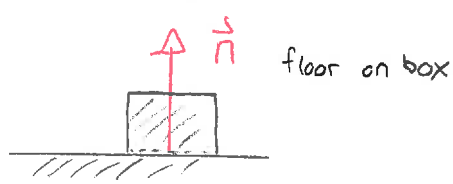
Forces

Interactions between objects are described using forces. A force is a vector with

1) magnitude equal to strength of force /push/pull
2) direction in direction of force.

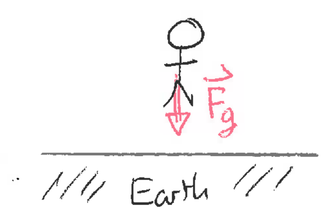
Part of the task of physics is to provide rules for constructing force vectors. Some examples are:

1) normal force ~ force exerted by one object in contact with another
   ~ direction = perpendicular to interface



2) tension Force ~ exerted by rope, cable
   ~ direction - along direction of rope.

3) gravity ~ exerted by one object on another by virtue of their masses - do not need to be in contact
   ~ near Earth's surface, force points to center



See Ch 5.2, 5.3

Quiz 1 95% ≀ 70% ~ 95%

Dynamical effects of forces

In order to quantify the strengths of forces, we will need to consider a larger question of what their dynamical effects are. In principle, we can address this by applying standard forces to standard objects and observing their subsequent motion.

A typical example considers standard springs stretched to standard lengths and acting on objects with known masses. Each spring will exert the same force and by varying the number of springs we can vary the forces.

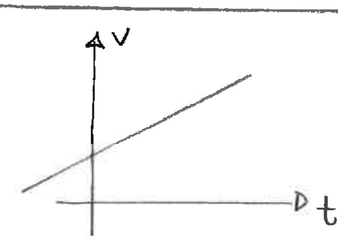
e.g. two springs

Demo Do this with cart + spring balances

Experiments indicate:

In the absence of any other interactions

1) the graph of v vs t shows that the object accelerates.



2) the acceleration is

a) inversely proportional to the mass of the object

b) directly proportional to the force exerted. So

$$a = \text{constant} \times \frac{F}{m}$$

Warm Up!

The constant can be fixed by setting the units of force. The units of force are Newtons (N) and are defined so that the constant is 1.

Thus a lone force of 1 N will cause an object of mass 1 kg to have acceleration $1\,m/s^2$.

A key point is:

Forces tend to produce accelerations

Forces tend to change velocity.

and a common misconception is that:

force ~~produces~~ velocity

Schematically:

Object interacts with surrounding objects $\longrightarrow$ described by force $\vec{F}$

Object has mass m

If only one force is present then object accelerates and acceleration is

$$\vec{a} = \vec{F}/m \quad \text{or} \quad \vec{F} = m\vec{a}$$

Demo PhET Forces + Motion $\longrightarrow$ Force graphs tab

- display a, v
- no friction, drag
- set $F =$ ~~zero~~ 50N
- observe a, v

Clearly a given value for force does not result in a given value for velocity. It results in a changing velocity.

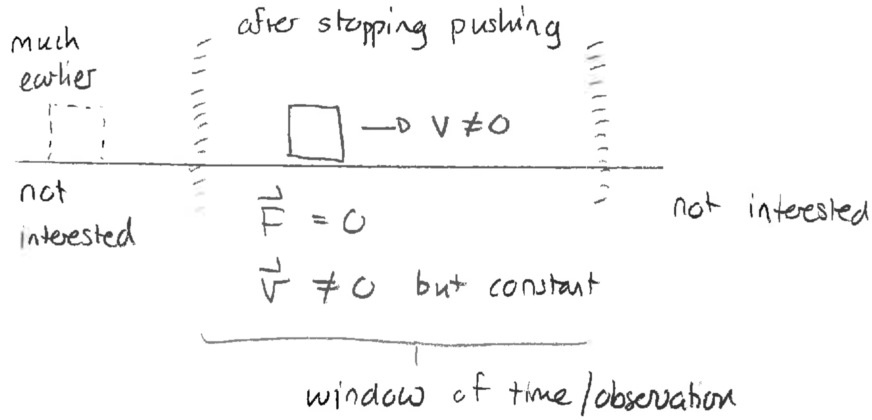
It is also possible to have non-zero velocity and zero force. This means

Force is not essential to sustaining velocity

Demo: Forces + Motion as before but with crate.

– Push + release

If we focus on the "window of time" after the force is removed, we can see that the object does move



This is an example of Newton's First Law which describes the default motion of an object.

The net force acting on an object is zero if and only if it moves with constant velocity

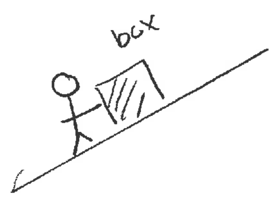
Quiz 2 90% || 90%

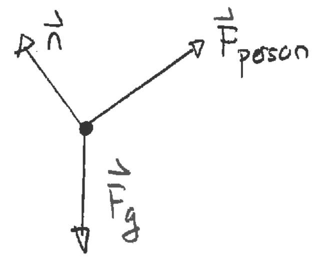
Demo: Hoop + balls.

Free body diagrams + net forces.

In general many forces act on an object, and there is a single force vector for each one. These forces can be represented by a <u>free body diagram</u> (FBD):

1) the object is represented by a dot
2) each force is represented by a vector whose tail is at the point where the force acts.





Then the net force acting on the object is the vector sum of the individual forces:

$$\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \dots = \sum \vec{F}$$

This gives meaning to Newton's First Law. More crucially it gives <u>Newton's Second Law</u>:

> If forces $\vec{F}_1, \vec{F}_2, \dots$ act on an object with mass m then the acceleration of the object is:
>
> $$\vec{a} = \vec{F}_{net}/m \qquad (\vec{F}_{net} = m\vec{a})$$
>
> where $\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \dots$

Warm Up 2